means may be taken into consideration, which comprises minimizing as much as possible the pinned layer stray magnetic field, or that is, making the upper and lower pinned layers have the same thickness in the Synthetic AF structure thereby to make the pinned layer stray magnetic field nearly zero. It further comprises enlarging Hin as much as possible so that the just bias could be in the current magnetic field for canceling the enlarged Hin. However, this means is undesirable. The enlarged Hin has some negative influences on external magnetic field response. The enlarged Hin shifts the linear region of the response and, in addition, reduces it. It will be good to control Hin to be small. However, fabricating spin valve films while the value is forcedly controlled to be an unnaturally large and constant one is extremely difficult in mass production and is unfavorable.

Since no high-conductivity layer is provided on the free layer at the side opposite to the side of the spacer adjacent to the free layer, the MR ratio is lowered when the free layer is an ultra-thin one, for the same reasons as in Comparative Case 1. Therefore, the film constitution of this Comparative Case 4 could not ensure satisfactory output, when applied to high-density recording heads. This is the essential problem with this film constitution.

For the two reasons of bias point and high output mentioned above, the spin valve film merely incorporating the

Synthetic AF constitution could not realize the use of ultra-thin free layers therein for high-density recording.

As has been described in detail hereinabove, we, the present inventors have clarified, through many simulations in various current magnetic fields, that the film structures of Comparative Cases 1 to 4 could not attain stable bias point and satisfactorily high output for spin valve films having an ultra-thin free layer for high-density recording. Through further studies and investigations, we have achieved the present invention. The constitution of the invention is described in detail hereunder.

Fig. 15 is a graph of the free layer thickness dependence of the bias point in the spin valve films of the invention, as compared with that in the spin valve films of the above-mentioned Comparative Cases. It is understood that the spin valve films of the Comparative Cases are all problematic in the bias point. The best bias point for spin valve films falls between 30 and 50 %. For satisfactorily high sensitivity, the bias point must fall within the defined range at a low Ms×t free layer.

However, the bias point in the Comparative Cases significantly oversteps the preferred range in the condition of low Ms×t. In addition, in the Comparative Cases, the bias point fluctuation relative to Ms×t is extremely large, and it is understood that the bias point is difficult to control in

those Comparative Cases.

As opposed to the films of the Comparative Cases, it is understood that, in the film of Example 1 of the invention, the bias point fluctuation is extremely small relative to Ms×t, and the bias point is all the time within the preferred range.

In Fig. 15, the calculated bias point values in Comparative Case 1 do not fall within the range between 30 % and 50 % even in the region where Ms×t is not smaller than 5 nanometer Tesla. This is because, in the actual region of low recording density for which a free layer having Ms×t of at least 5 nanometer Tesla is used, the MR height is large. Concretely, this is because the MR height for low recording density heads is larger than the range of from 0.3 μm to 0.5 μm for the high recording density to which the present invention is directed.

Anyhow, it is obvious that, in the region where Ms×t is at most 5 nanometer Tesla, the bias point designing for the films of the invention is much superior to that for the films of the Comparative Cases.

Fig. 16 is a graph of the MR ratio in the structures of Comparative Cases 1 to 4 with the product of Ms×t only in the free layer being reduced. In this, the MR ratio as plotted in the vertical axis is nearly proportional to the vertical axis of Fig. 9 for the transfer curve. For comparison, the data of Examples 1 and 2 of the invention to be mentioned hereunder are also plotted in Fig. 16.